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SIMPLE RADIATION STUDIES in Biology

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Schmidt **Christensen**

Radioisotopes are a part of modern biological science. Radiation studies can be carried out without great expense. Thus they are available for the secondary level. Projects are easy to develop and can be adapted to any area of biological science. We would like to encourage all biology teachers to incorporate the use of radioisotopes into their programs.

Introduction

The scientific and technological progress in the United States in the last fifteen years has been greatly increased by the use of radioisotopes. Today, isotopes are used in all branches of science and industry. Radiation is now a common tool in medical diagnosis and therapy. Isotopes are being utilized in physical, chemical and life science research. Industry is interested in the development of more and more applications of isotope use. As the use of this "tool" increases, the direct and indirect effects upon all citizens will continue to grow.

If we can agree that radioisotopes are becoming more involved in the daily life of each person in this country, we can see the implication to science teachers. If a teachers' primary aim is to prepare his students for life in our society, then it follows that with an understanding of radioisotopes and radiation, fear is changed to respect for it as a useful tool. The hazard of isotope use in tracer experiments is so slight that common sense and good judgment coupled with a small amount of training will make their use in the secondary science program routine and we think "a must".

Materials Needed

The mistaken idea that expensive equipment is needed for radiation studies has kept many teachers from doing experiments with these materials. The fact is that the use of x-ray film will result in not only satisfactory but startling results. The list of materials needed for a starter is short, including

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Cameron Christensen received a B.A. Degree from the State University of Iowa, an M.S. from Washington University in St. Louis, and has done additional graduate work at State College of Iowa, the State University of Iowa, Iowa State University, Ball State Collgee, and Purdue. He has held office in the Iowa Science Teacher's Association, and is presently teaching at Rockwell City, Iowa.

the following:

1. A radioactive material (P^{32}, radioactive phosphorus is suggested because of availability and short half life)
2. X-ray film and film holders
3. Developing chemicals for film.
4. Planchets and covering materials.

To keep cost at a minimum it is suggested that a start be made with one commercial kit (see sources list). From this point, any number of hand-

A positive test for radioactivity. Ashed plant wrapped in saran at right. Black streak on exposed and developed x-ray film at left.

made kits can be developed to meet the needs of the school at a very low cost. Kodak medical x-ray film of any grade will work, but the "no-screen" type is most acceptable because it is a fast film and also can be developed under a safety light. This film can be processed with Kodak Rapid X-ray developer and fixer; simple directions are included on the packages. Planchets (holders for the radioactive materials) can be made of any handy shallow containers such as metal or plastic bottle caps. Much of the other material could be obtained through the local hospital, doctor or camera shop. In the "sources" list are some commercial sources for the materials.

Projects

There is no limit to the variety of projects you can adapt to the use of radiation and radioisotopes. We suggest (see appendix) projects in radioecology, translocation in plants, and calcium uptake in guppies as examples of the type of work that can be done.

The autoradiograph: It is wise to start with a simple direct experiment or procedure to develop a technique of handling the materials. By injecting a large insect (such as a grasshopper or cockroach) with P32 and exposing it to a film, the final developing of the film will produce an impressive autoradiograph of some biological materials. This simple procedure will give enough training to allow the teacher and student to branch out into the more complex studies. Select a small work area which can be left undisturbed for a period of several days. Cover the area with Saran wrap and then some type of absorbent paper towling. Place the proper "warning radiation" signs (see appendix) around the area and do not allow anyone to remain in this area for an extended length of time. Inject an insect with P^{32} and after several minutes sacrifice it in a killing jar. Affix the insect with a rubber band to the film holder containing a sheet of x-ray film. Plastic or rubber gloves are used when handling the materials during injection and mounting. Put the "loaded" x-ray film aside for a period of time (8 to 18 hours). It will take several tries to obtain the correct exposure time for excellent results. All disposable materials can be wrapped in the original layer of Saran wrap, used to cover the work area, and stor-

Two types of x-ray film holders. Upper and right; commercial type of light tight holder. Lower left, home made holder made of cardboard and manilla envelope with rubber band.

ed for a period of ninety days. A large plastic garbage can will make an excellent storage container. After the storage time is over, the radiation level is so low that the materials can be disposed of by burning or burying.

Soures

Many scientific supply houses are now producing materials to be used with radioactive materials. The following list simply gives the names of a few places that specialize in this area and which we know to be cooperative.

1. Atomic Laboratories, Inc., 3100 Crow Canyon Road, San Ramon, California 94583—No. 71741 X-ray photography kit, $20.00.

2. Atomic Corporation of America, 14725 Arminta Street, Panorama City, California—Atomkit No. 2, Radioautographs, 5.95; 10 uc P^{32}, $4.00; x-ray film and holders available.

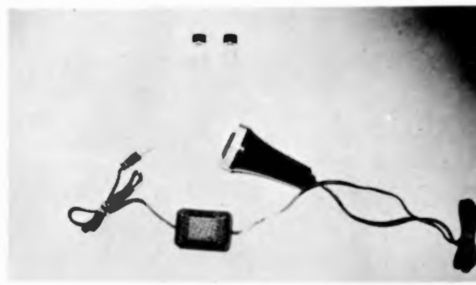
3. Bio-rad Laboratories, 32nd and Griffin Avenue, Richmond, California.

4. Nuclear-Chicago Corporation, 223 West Erie Street, Chicago 10, Illinois—Large catalog available; all kinds of equipment and materials available.

Basic equipment needed for radiation studies in high school biology. X-ray film, holder, developer, developing trays, plastic dishes for experimental materials, hypodermic syringe for injections and saran and plastic disposable gloves for handling materials.

Conclusions

This paper is prepared only to act as a stimulus and introductory guide to teachers and is in no way a complete coverage of the uses of isotopes in secondary classrooms. Many plant and animal materials can be used. An isotope can even be traced through the metamorphosis of an insect. Of course, chemistry and physics classes can use these materials also. For example, an isotope can be traced through a series of chemical reactions. The only limit to the use of isotopes is the instructor's ingenuity and imagination.



Two sources of radiation readily available to the average high school. Ultraviolet lamp and radioactive isotope available from commercial supply house.

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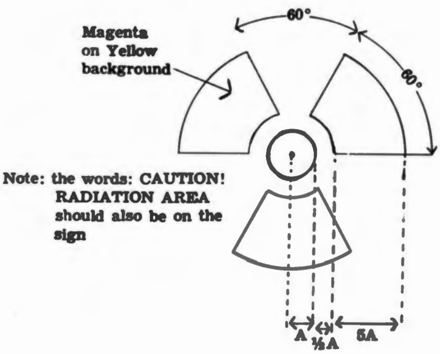
APPENDIX



Appendix II

Radioecology—"Food Webs"

In biological communities there is a flow of energy from the primary producers through the various consumer levels and back into the environment via decomposers and heat loss. A complicated food web is present in most cases involving a series of "eating and being eaten" situations involving the various organisms. Since phosphorous is found in a living organism, the primary producers can be "tagged" with P^{32} and the flow of this element can be traced through the food web. In general the primary producers are the photosynthesizing plants. We would emphasize the value of using aquatic plants because of the ease of "tagging" them simply by growing them in the P^{32} solution for a day or two. Other plants can be "tagged" by leaf and stem injections of P^{32} or growing them in a container of P32 and water solution. Five uc P^{32} in 200 ml water will "tag" a large amount of plant material.

Procedure:

1. Tag the producers (plants). Either grow aquatic plants in radioactive solution (200ml H_2O plus 5 uc P^{32}) or inject the solution into plant stem and leaves. Note: this is the only level directly exposed to the isotope!
2. Verify that plants are tagged. Ash one gram of plant by heating in a planchet, wrap the ashes in Saran and affix to x-ray film for exposure.
3. Feed producers to primary consumers (herbivores). Use a variety of combinations to determine which plant is used by which container.
4. Verify transfer of energy to second level. (Same procedure as in No. 2 above).
5. Feed primary consumers (herbivores to secondary consumers (carnivores). Again use a variety of combinations to determine preference and maximum transfer.
6. Verify transfer of energy to third level. Same procedure as in No. 2 above.

Suggested organisms:

Producers	**Primary consumers**
Spirogyra	snails
Cladophora	crayfish
Ceratophyllum	Daphnia
Elodea	insect larvae
Lemna	rotifers
Grasses & legumes	fish & adult insects

Secondary consumers

frogs
salamanders
birds
predacious insects
fish

(Some organisms are detritus feeders; detritus can be made easily by grinding up some radioactive plant and animal materials).

From the data collected a "food web" diagram following the pattern suggested below can be constructed.

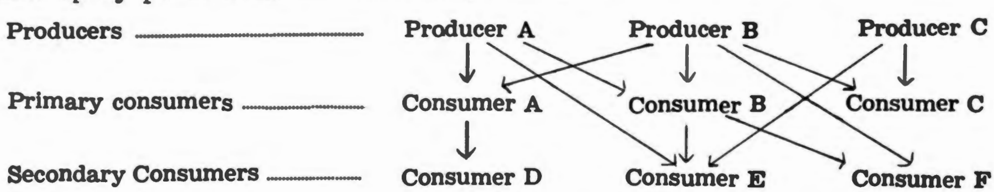
Flow Diagram for Project

"tag" producers → verify "tag" → feed to primary consumer → verify transfer → feed to secondary consumer → verify transfer

This shows the interlocking nature of the various food chains found within a given community.

P^{32} Translocation In Plants

The use of isotopes has made it possible to trace the movement of minerals about a plant during its normal life activities. It can be shown that plant food can be moved downward as well as upward in a plant stem. Evidence has been gathered by the use of isotopes that during periods of high plant activity, minerals can be absorbed by the leaf surfaces as well as through roots. Fruit growers have applied this principle and now spray plant foods on their trees during the flowering and fruiting seasons to increase production.



To prepare the plants, place them in distilled water for several days. Tomato or peppermint plants seem to give the most effective results. Plant tagging can now be accomplished by placing them in a radioactive solution (200 ml H_2O plus 5 uc P^{32}) for 24 hours to obtain complete distribution. The roots may be removed for easier handling with little effect on the results. Remove the leaves after one day and tape them in order to a 3" x 4" paper card and wrap in Saran wrap. Affix the card on x-ray film for 24 hours and develop.

Be sure to wear protective gloves when handling active materials directly. Save all contaminated plant materials at least 90 days before disposal.

Other methods of plant exposure can also be used. Inject the radioactive material high up in the stem and check the lower leaves the next day. "Paint" the P^{32} on one of the larger leaves and after several days produce autoradiographs of the other leaves to see if the material has been absorbed.

Calcium Uptake in Guppies

Calcium is taken into a fish body at a fairly slow rate which makes it easy to find where the element concentrates after different lengths of exposure. Guppies are best used because of their small size and hardiness. The males seem to give the best results because of their flat bodies.

Place guppies in a container of radioactive solution (400ml H_2O plus

IMPORTANT NOTICE

The revised constitution, which was adopted April 1 by a mail vote of the members, will be published in the Fall, 1966 issue of THE JOURNAL.

Mason City Meeting A Huge Success . . .

The North Central Science Congress on Jan. 22 drew several hundred scientists, teachers, and students.

Vern Gunderson, Regional Director for Iowa Science Teacher's Association, organized and directed the Science Congress.

Marvin Gould, Engineering Extension Service, Iowa State University and representatives of Jets talk to students about the Jets program.

Dr. Zaffarano looks at the Latta's 3-M dislay.

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10 uc Ca^{45}) for differing periods of time (24 hours - 48 hours and 72 hours.) As each fish is removed, sacrifice it in a 70% alcohol solution to which a small amount of formalin has been added.

This should harden and prevent spoilage of the tissues if they are left in this solution for two hours. Wash and wrap the fish in Saran wrap after it is removed from the fixing solution. It can then be affixed to the x-ray film holder for a period of from 24 to 48 hours. The longer time may be needed since the beta particle energy is much lower than that of P^{32}. Due to the fact that some of the Ca^{45} will adhere to the scales, a faint outline of the fish should be present in most cases.

The uptake of this radioactive material should first be present in the eyes and gills. Later it will show a general distribution throughout the body and finally a definite bone pickup should result. Because of the small size it is advisable to cut the developed film and mount in 35 mm slide holders. They can then be projected on a screen to show more detail.

Protective gloves are needed when handling any of these radioactive materials directly. The long half-life will require all contaminated material to be stored for a year before disposal.